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Met O 11 Technical Note No.21

Secular changes in the frequency of meteorological conditions favourable for sea surges along the east coast of Britain

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Introduction.

The authorities responsible for the Flood Warning Organisation and coastal defences are interested in the problem of whether surges have been occurring more frequently in recent years than in the past. It is not possible to determine long term trends from actual surge records as there are no very long records available. In addition there is evidence that there have been changes in mean sea level during the last century: for example the southeast of England is now some 6 inches or more lower with respect to mean sea level than it was 100 years ago, and this is obviously a complication when actual tidal records are being studied.

An alternative way to find an answer is to define the meteorological conditions associated with, or favourable for, surges along the east coast and then to examine the changes in the frequency of these favourable meteorological conditions over the period for which suitable meteorological information is available. This alternative was the approach adopted in the present investigation.

The objective definition used in the investigation.

Dines (1), in an investigation carried out after the 1928 flood in the Thames Estuary, suggested that the following rule could be used to determine the occasions when the water at Southend would be raised four feet or more - "The onset of a geostrophic wind over a considerable part of the North Sea of 60 mph or more from between northwest and north".

A slightly modified criterion was used in extracting data for an investigation carried out by Met O 3 at the end of 1953, following the disastrous flood of Jan 31-Feb 1953: occasions were selected when 'a geostrophic wind between northwest and northnortheast reached 40 knots or more and covered the greater part of the North Sea'. At the start of this present investigation it was suggested a definition which was less restrictive should be used, but that it should be as objective as possible. From discussions with the officers of the Flood Warning Organisation working at Bracknell it also seemed probable that for a surge to occur it was not necessary for such a large part of the North Sea to be covered by a favourable airstream as had been considered by earlier workers: the duration for several hours of a favourable wind over a part of the western North Sea was thought to be sufficient. With the above considerations in mind the following objective definition was accepted for the purpose of this investigation.

"Any occasion when, on the morning chart (06, 07 or 08h as appropriate) of the DWR series, the geostrophic wind measured over an area of 200 n.m square centred above

either point A (53°N,02°E) has a direction in the sector northwest to east through north and reaches at least 40 knots

or point B (57°N,01°W) has a direction in the sector northwest to northeast through north and reaches at least 40 knots

will be regarded as an occasion when meteorological conditions favoured a sea surge on the east coast". It was further agreed that the period of the year to be examined would be the eight month period from September to April inclusive, corresponding to the normal season for which the FWO issues warnings.

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The main limitation resulting from the use of the Daily Weather Report (DWR) series of charts was that the criteria used should apply to one chart daily - this was necessary as earlier DWR carried only one chart: the use of two points A and B to some extent offset this limitation. A further slight limitation was that the size of the area examined depended to some extent upon the isobars drawn on the DWR series: the side of the square could not have been reduced much below 200 n.m as the isobars on some charts would not then have permitted a satisfactory wind speed estimation to be made.

Extraction of this data.

Charts have been issued in the DWR series since March 1872 and so the period examined was from that date until the end of 1962.

Details concerning the precautions taken to ensure that the definition was applied uniformly throughout the extraction, irrespective of changes in mapping practice, etc., have been given briefly in Appendix I. These precautions were necessary to avoid obtaining spurious effects in the results.

Check on the reality of the definition.

Once the catalogue of occasions had been compiled and before working up the results it seemed desirable to carry out a check on the reality of the definition as a means of selecting occasions for sea surges. A record is maintained by the Flood Warning Organisation at Bracknell of surges of 2 ft or more at certain east coast ports during recent years: the surges recorded in this way were therefore available for comparison with these occasions selected by the meteorological definition. A comparison was therefore drawn up for the five winter seasons 1957/8, 1958/9, 1959/60, 1960/1 and 1961/2. Since only the 06h chart had been used for the extraction of the meteorological occasions it seemed reasonable to assume that there was association between surge occurrence and the meteorological occasion selected if the required meteorological conditions either preceded the surge by less than 24 hours or were still prevailing at the first opportunity of chart measurement after the surge occurrence. Using this criterion for association the analysis for the five winter seasons is shown in Table I.

Table I. Comparison of surge occurrences with meteorological occasions selected (in the five winters 1957-1962)

Height of surge (minimum)	Number of surges reported	Number associated with selected meteorological occasions
2 ft	71	34
3 ft	53	30
4 ft	21	18
5 ft	10	8
7 ft	3	3

The total number of occasions selected meteorologically was 80, which is of the same order as the actual number of surges of 2 ft or more and the contingency table is given in Table II.

Table II. Contingency table for the five winter seasons

		Number of occasions selected meteorologically as favourable	unfavourable	Totals
Actual number of occasions	with surges (2ft or more)	34	37	71
	without surges (2ft or more)	46	1094	1140
	Totals	80	1131	1211

/Tables

Tables I and II show that there is some support for the claim that this definition selects occasions which have some reality with actual surge occurrences. By the use of one parameter, measured once daily, one could not expect a much higher degree of association than that shown.

Appendix II gives the occasions and times of the largest surges at the east coast ports for which records are available when surges of 4 ft or more were recorded during the five winter seasons: also included in this appendix are the wind data for points A and B, if the conditions specified in the definition were satisfied.

Evaluation of the results.

Appendix III is the catalogue of the occasions selected by using the definition over the ninety years period from March 1872 until 1962: on each occasion there is an indication as to whether the conditions were satisfied at points A and/or B: the code also indicates whether the wind speed was 50 kts or more and whether the wind direction was in the sector northeast to east.

The season, for flood warning purposes, comprises the eight months period September to April, so the results of this investigation are presented in terms of seasonal totals and running means over five seasons (but referred to as 10 year running means for convenience).

Figure 1a shows the number of days each season when the specified conditions were satisfied and figure 1b the number when the wind speed was 50 knots or above. Superimposed on both these histograms are the curves showing the 10 year running means. In figure 1a there is a noticeable maximum in this curve in the first decade of this century followed by three decades with the 10 year running mean lower than the long term, 90 year, average: this minimum is followed by an increase in the frequency in the last two decades. Figure 1b, on the other hand, is not so noticeably peaked and it might be argued that the differences in this case from the appropriate long term average are not greatly different from those which might have arisen by chance.

Figure 2a shows the number of 'events' each season, counting independent occasions as 'events' (i.e. a sequence of consecutive days when the meteorological definition was satisfied is regarded as only one 'event'). Figure 2b shows the number of days when the meteorological definition was satisfied simultaneously at points A and B. The 10 year running means have also been superimposed on these diagrams: figure 2a is similar to figure 1a: in the case of figure 2b there are a greater number of maxima and minima, with again as in figure 1b, the suggestion that such a variation from the long term average could have arisen by chance.

It seemed reasonable to examine the hypothesis that there was no significant change in decadal frequency, testing this hypothesis statistically on the nine ten season totals which cover the period of the investigation. Table III shows the result of the X^2 test applied to these four sets of data (figures 1 and 2).

Table III. X^2 test applied to the data in figures 1 and 2

	Expectation per decade	X^2
All occasions (figure 1a)	118.1	24.2
All events (figure 2a)	96.9	14.27
Occasions 50 knots or more (figure 1b)	35.2	7.54
Occasions when definition is Satisfied at pts A and B (figure 2b)	24.8	3.29

For eight degrees of freedom, Fisher (2) gives the following significance values (to two decimal places):-

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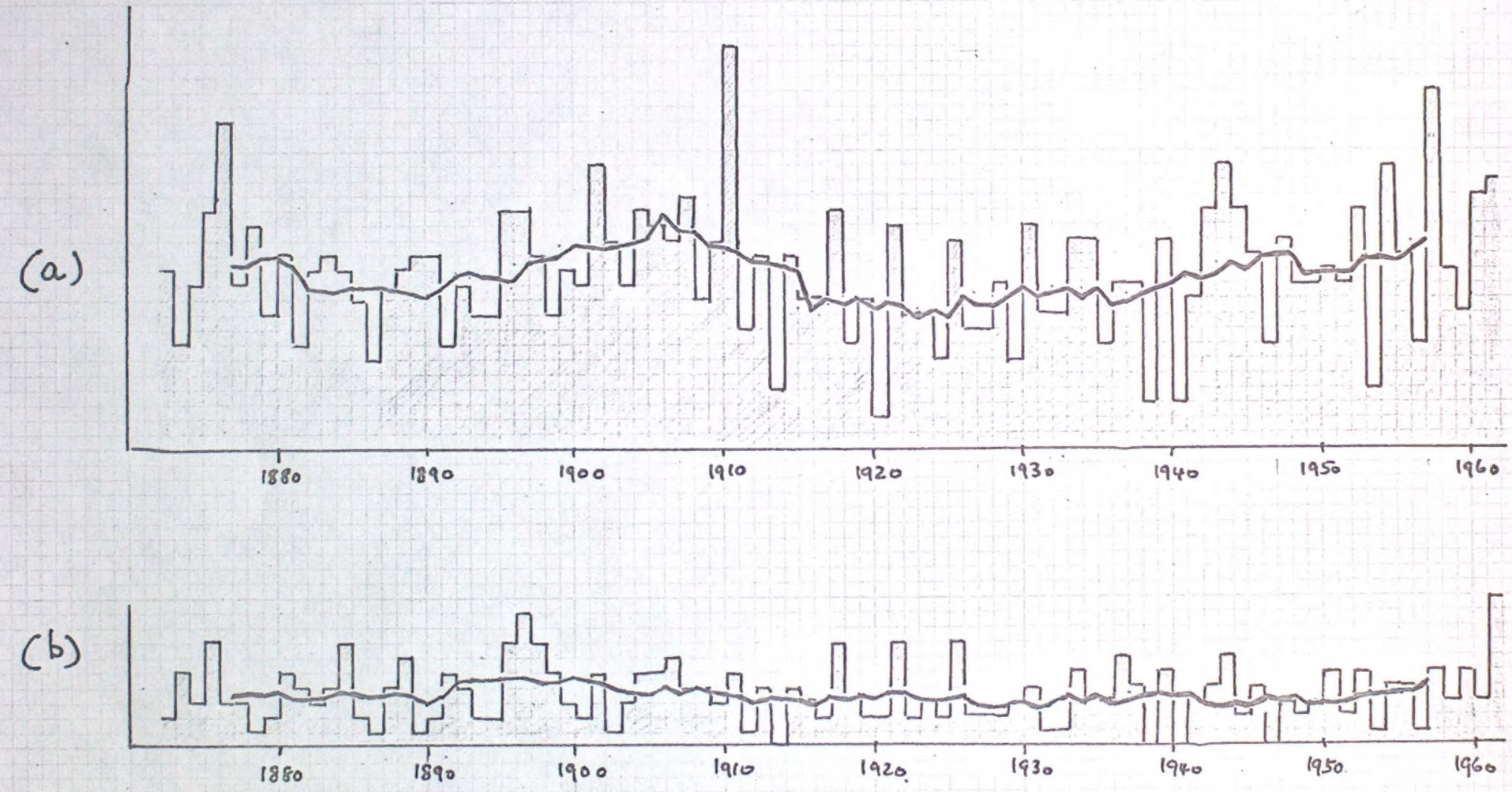

Figure. 1. Seasonal totals and 10 year running mean curves for

(a) all occasions when favourable meteorological conditions existed

(b) occasions when favourable meteorological conditions existed and wind strength was 50 kts or more

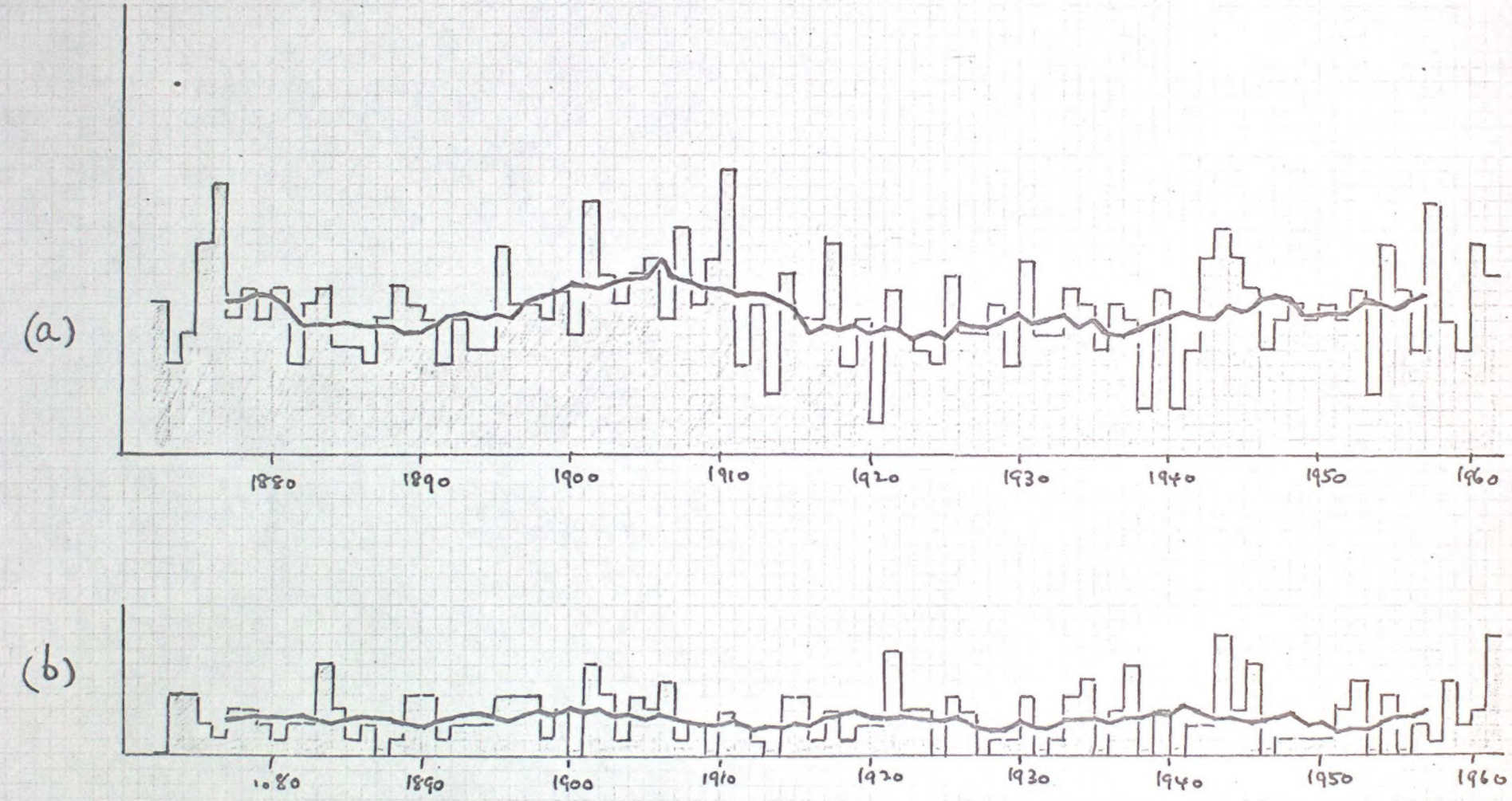

Figure 2. Seasonal totals and 10 year running mean curves for
(a) 'events' when favourable meteorological conditions existed
(b) occasions when favourable meteorological conditions existed at both points A and B

1 per cent level	20.09
5 per cent	15.51
10 per cent	13.36
50 per cent	7.34
90 per cent	3.49
95 per cent	2.03
99 per cent	1.65

It will be seen therefore that the observed differences from the long term average in figure 1a could have arisen by chances less than once in a hundred times and the differences are therefore probably highly significant.

In the case of occasions with wind stronger than 50 knots and also in the case of occasions when the definition was satisfied simultaneously at parts A and B, it is not possible from this particular test to say that the differences from the long term mean are significant.

The peaks in the curves are largely due to the contributions to the eight month season from the two months January and February as Table IV shows.

Table IV. Comparison between 'occasions' in the eight month period and those in the months January and February

5 season period	All occasions	January occasions	February occasions	Jan and Feb occasions
1872- 7	67	7	12	19
1877-82	55	4	5	9
1882- 7	53	9	1	10
1887-92	56	8	7	15
1892- 7	60	12	3	15
1897-02	64	12	8	20
1902-07	70	11	19	30
1907-12	76	13	12	25
1912- 7	50	9	3	12
1917-22	50	8	3	11
1922- 7	47	3	4	7
1927-32	49	7	3	10
1932- 7	55	6	14	20
1937-42	41	3	7	10
1942- 7	71	13	14	27
1947-52	59	11	6	17
1952- 7	59	11	11	22
1957-62	80	17	20	37

Actual surges recorded by the Flood Warning Organisation also showed an increase in frequency in January and February: in the last five winter seasons 1957-62, for example, 38 out of the 71 surges occurred in these two months.

Conclusions.

The investigation led to the following conclusions:-

(i) The frequency of occasions when meteorological conditions were 'favourable' for sea surges in the late 1950's and early 1960's has been above the long term (ninety year) average:

(ii) the frequency in recent years (up to 1962) has not reached the level attained in the first decade of the century:

(iii) after the 1901-11 peak in the frequency, there was a period of about 30 years when frequencies generally were below the long term average:

(iv) the ninety year period is probably too short and the indications

/insufficient

insufficient to justify attempting a forecast as to the future frequencies by any extrapolation methods:

(v) the observed peaks in the frequency are largely due to the increased frequency of 'favourable' conditions during the months of January and February.

References

(1) Dines, J.S. 1929. Geophysical Memoir No. 47

(2) Fisher R.A. 1954. Statistical Methods for Research Workers 12th Edn.

Appendix I.

Comments regarding the data extraction.

I. Interpretation of the specification.

Most of the charts presented no difficulty in applying the definition, but there were three types of situation which had to be allowed for, in order to keep the set of statistics consistent:

(i) when there was an airstream of correct specification about point A and B but with A or B near the edge of, but within, this stream: these occasions were included with appropriate comment since exclusions would probably have introduced a bias in favour of later charts, when the North Sea data are generally more complete. Cases where points A and B were just outside the stream were however excluded.

(ii) When a depression was less than 100 n.m from point A or B and thereby affected the evaluation of the mean wind: these occasions were also included (appropriately marked) on the same grounds as type (i).

(iii) When the chart was not drawn in sufficient detail to determine the mean wind properly: these occasions had perforce to be excluded but were, fortunately, a very small number: there were a few occasions when it seemed that the mean wind must be at least 40 kts and these occasions were included.

II. Fatique.

Two independent extractions were made. The first set was made taking the years in climatological order, but it was obvious that as the work progressed, fatique was resulting in a lower number of occasions being picked up, than should have been the case. For the second set of extractions, three persons were employed and the years were examined in random order to remove or at least to spread any fatique effects uniformly over the ninety years. The combined catalogue of occasions was then completely double checked and spot checks were also made on a few years to determine if the extractions had proved satisfactory. Appendix III represents the final double checked catalogue of occasions.

Appendix II

Details of surges of 4 feet or more in the five winter seasons 1957-62.

Maximum surge from FWO record (and date and time)			Conditions if meteorological definition satisfied at A	B
5.4 ft	2100	22/11/57		22/11 NNW 40
5.0	0100	10/ 1/58		See Note 2
4.4	0400	19/ 1/58		19/1 NW 40
4.7	2200	5/ 2/58		6/2 NNW 40
5.4	0900	17/ 2/58		17/2 NNW 40
5.2	2400	25/ 2/58	25/2 ENE 60	
5.4	0300	3/ 1/59	3/1 NW 40	3/1 NNW 40
4.6	1500	16/ 4/59		
5.0	0100	28/10/59		28/10 N 70
5.2	2100	30/12/59		See Note 3
7.5	1300	20/ 1/60	20/1 NW 80	20/1 NNE 60
4.7	0100	12/10/60	12/10 NNW 50	12/10 N 50
4.6	2200	18/ 3/61		18/3 NNW 40
7.4	2400	20/ 3/61	21/3 N 40	20/3 NW 40
4.2	0600	27/ 3/61		27/3 NW 40
4.5	2300	18/10/61	18/10 NNW 50	18/10 NNE 50
4.2	0300	3/11/61	3/11 NNW 40	3/11 N 50
4.0	1800	5/12/61		5/12 N 60
4.6	2300	12/ 2/62		12/2 NW 60
				13/2 N 40
7.7	2000	16/ 2/62		16/2 NW 60
			17/2 NNW 60	17/2 NNW 50

Notes 1. Speed 40 indicates a speed equal to or greater than 40 knots but less than 50: similar connotation should be placed on entries of 50, 60, 70 and 80.

2. On 9/1/58 wind at B was just too backed to qualify.

3. On 30/12/59 wind at A and also at B was just too far backed to qualify.

4. No comments are available on extraction sheet for 16/4/59.

Appendix III. Catalogue of occasions selected

Legend a, b indicates definition satisfied at point A, B respectively with speed 40 knots or above but less than 50 knots.

A, B indicates definition satisfied at point A, B respectively with speed 50 knots or above.

( ) indicates that wind direction at point A or B whichever is appropriate, was assumed as in the sector NE-E.

Note (x) charts were not included in DWR series before March 1872 so the first year 1872 is incomplete.

1872(x) 19 Mar a, 4 Apr b, 9 Apr A, 21 Apr (a).
25 Sept B, 26 Sept a, 11 Nov a, 14 Nov (a), 4 Dec a, 11 Dec a,
18 Dec (a).

1873 3 Feb (A), 4 Feb (b), 12 Feb a, 22 Feb b, 27 Feb a.
16 Sept A, 19 Sept AB, 22 Nov ab, 23 Nov b, 30 Nov AB, 16 Dec B.

1874 20 Mar Ab.
22 Oct aB, 23 Oct a, 10 Nov b, 11 Nov aB, 12 Nov a, 16 Nov a, 1 Dec b
9 Dec A.

1875 22 Jan ab, 27 Feb (a), 20 Mar ab.
27 Sept B, 7 Oct b, 15 Oct (a), 11 Nov a, 19 Nov (B), 20 Nov Ab
21 Nov (A), 6 Dec (a), 25 Dec Ab.

1876 18 Jan B, 7 Feb (a), 24 Feb a, 10 Mar B, 18 Mar a, 11 Apr b, 14 Apr (a).
11 Sept b, 12 Sept b, 13 Sept b, 19 Sept b, 1 Oct (a), 31 Oct b,
13 Nov (a).

1877 11 Jan (a), 15 Jan a, 26 Jan a, 30 Jan B, 31 Jan a, 11 Feb b, 20 Feb a,
24 Feb b, 28 Feb A, 7 Mar (B), 8 Mar b, 13 Mar ab, 21 Mar (a), 1 Apr b,
17 Apr (a).
12 Oct ab, 31 Oct a, 23 Nov AB, 25 Nov a, 31 Dec A.

1878 24 Jan b, 25 Jan b, 8 MarAB, 12 Mar a, 29 Mar (a), 30 Mar a
29 Oct ab, 6 Nov b, 9 Nov a, 15 Nov a(b), 16 Nov A(b), 17 Nov b,
21 Dec b, 22 Dec a.

1879 1 Jan b, 5 Jan a, 26 Feb a, 22 Mar (a), 23 Mar (a), 25 Mar (a), 10 Apr (a).
25 Sept a, 4 Oct b, 18 Oct a, 21 Oct ab, 2 Nov b, 6 Nov a, 12 Nov Ab.

1880 26 Feb B, 28 Feb b,
15 Sept (B), 29 Oct a, 10 Nov a, 19 Nov A, 9 Dec b, 10 Dec B, 12 Dec B,
14 Dec ab, 24 Dec B, 25 Dec b.

1881 6 Feb a, 22 Mar a, 2 Apr (a),
13 Oct B, 17 Nov B, 18 Dec A

1882 19 Feb ab, 22 Mar ab, 25 Apr b, 26 Apr A
28 Oct (A), 29 Oct ab, 7 Nov a, 9 Nov b, 11 Nov a, 14 Nov (a), 15 Nov (a),
28 Nov b, 8 Dec (a).

1883 26 Jan (b), 28 Jan A, 6 Mar AB.
1 Oct b, 4 Oct (A)b, 18 Nov A, 4 Dec ab, 11 Dec ab, 12 Dec Ab, 16 Dec ab,
19 Dec ab.

1884 24 Jan Ab, 28 Jan a, 2 Feb (a), 11 Mar (a), 21 Mar b.
11 Oct Ab, 12 Oct b, 26 Oct B, 27 Oct aB, 20 Nov b, 21 Nov A, 20 Dec A.

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1885 11 Jan (B), 12 Jan aB, 20 Mar b, 8 Apr a, 9 Apr a.
11 Sept (a), 12 Oct b, 13 Oct aB, 14 Oct a, 29 Oct b, 5 Dec b.

1886 8 Jan B, 9 Jan a, 14 Jan a, 3 Mar b.
1 Dec ab, 4 Dec b, 13 Dec b, 23 Dec A.

1887 1 Apr ab, 6 Apr (a).
10 Oct (b), 11 Oct A, 12 Oct b, 24 Oct b, 30 Oct A, 17 Dec B.

1888 26 Jan a, 16 Feb (a), 12 Mar A, 17 Mar a, 19 Mar (a).
30 Sept B, 5 Oct B, 13 Oct b, 21 Nov b.

1889 7 Feb b, 9 Feb AB, 14 Feb B, 19 Feb b, 13 Mar B, 26 Mar B, 27 Mar a,
2 Apr b.
25 Sept AB, 28 Sept b, 29 Sept b, 27 Oct (a), 25 Nov b.

1890 27 Jan b, 27 Feb b, 6 Mar b, 7 Mar b, 9 Mar ab, 20 Mar ab, 8 Apr b,
9 Apr ab.
16 Oct a, 18 Oct ab, 27 Oct ab, 15 Nov b, 24 Nov aB.

1891 14 Jan b, 25 Jan Ab, 26 Mar b, 27 Mar b, 28 Mar a, 29 Mar b, 30 Mar a,
17 Apr a.
21 Sept (B), 11 Dec B.

1892 2 Jan b, 3 Jan aB, 6 Jan B, 28 Jan a, 18 Feb A,
8 Oct b, 10 Oct a, 22 Oct a, 23 Oct Ab, 30 Nov b, 4 Dec aB, 5 Dec b.

1893 21 Jan a, 22 Feb A, 10 Mar B, 18 Mar b,
24 Sept ab, 18 Nov B, 19 Nov aB, 20 Nov (a), 23 Nov b, 26 Nov b.

1894 23 Jan b, 12 Feb b, 6 Mar b,
13 Nov A, 20 Dec a, 29 Dec b, 30 Dec b, 31 Dec aB.

1895 23 Jan ab, 25 Jan a, 22 Mar b, 7 Apr b.
4 Oct b, 11 Oct b, 24 Oct b, 23 Nov b, 25 Nov (a), 6 Dec B, 7 Dec AB,
8 Dec ab, 10 Dec B, 13 Dec b.

1896 16 Jan b, 22 Jan B, 7 Mar Ab, 12 Mar B, 27 Mar A, 13 Apr ab.
23 Sept B, 24 Sept a, 11 Oct b, 16 Oct (A), 8 Nov (a).

1897 22 Jan (b), 23 Jan (A), 25 Jan aB, 26 Jan a, 27 Jan b, 28 Jan AB,
21 Feb Ab, 23 Mar B, 29 Mar AB, 30 Mar B, 18 Apr a,
11 Oct b, 12 Oct b, 15 Nov B, 29 Nov AB.

1898 31 Jan Ab, 3 Feb ab, 17 Feb aB, 20 Feb b, 2 Mar a, 19 Mar b, 24 Mar (B),
25 Mar (A), 26 Mar (A),
8 Dec B, 15 Dec B, 28 Dec b, 30 Dec a

1899 17 Jan AB, 22 Mar a, 29 Mar b, 8 Apr A, 15 Apr (B)
22 Sept a, 13 Oct B, 9 Nov b, 2 Dec aB

1900 10 Jan ab, 18 Jan a, 25 Jan a, 14 Feb A, 20 Feb b, 21 Feb ab, 13 Mar b,
16 Mar b.
2 Sept b, 14 Oct b, 15 Oct a, 27 Oct A, 18 Nov (a), 29 Dec a, 31 Dec (A)

1901 29 Jan b, 30 Jan b, 20 Mar (a), 21 Mar (a)
15 Sept a, 7 Oct aB, 9 Oct ab, 14 Nov A, 28 Nov b, 30 Nov b, 1 Dec a,
14 Dec (ab), 18 Dec b.

1902 5 Jan ab, 6 Jan b, 16 Jan ab, 26 Jan AB, 29 Jan a, 1 Feb (a) 2 Feb (a),
15 Mar a, 25 Mar A, 6 Apr A.
13 Sept ab, 17 Oct b, 19 Dec a.

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1903 11 Jan b, 2 Feb aB, 14 Feb a, 3 Mar ab, 5 Apr b, 7 Apr b, 12 Apr b,
13 Apr b, 14 Apr ab, 16 Apr b, 24 Apr a
11 Sept A, 24 Nov b, 26 Nov a

1904 15 Jan b, 16 Jan ab, 17 Feb (a), 22 Feb a, 2 Mar (a), 25 Mar (a),
6 Apr B, 25 Apr B.
6 Oct Ab, 6 Nov b, 8 Nov AB, 22 Nov b, 23 Nov b, 30 Dec B

1905 7 Jan a, 12 Jan b, 25 Jan b, 31 Jan Ab, 1 Feb b, 2 Feb AB, 11 Feb b,
19 Feb b, 20 Feb b, 24 Feb b.
30 Sept b, 5 Oct b, 6 Oct AB, 13 Oct b, 16 Oct b, 27 Nov B

1906 19 Jan ab, 3 Feb B, 4 Feb ab, 9 Feb a, 11 Feb B, 20 Feb a, 9 Mar b,
12 Mar B, 19 Apr (a).
9 Nov b, 30 Nov b, 1 Dec Ab, 10 Dec ab, 25 Dec b, 26 Dec b, 28 Dec (B)

1907 4 Jan ab, 30 Jan aB, 31 Jan a, 13 Feb A, 20 Feb B, 21 Feb AB, 22 Feb b
3 Sept b, 13 Nov b.

1908 9 Jan a, 29 Jan b, 31 Jan B, 1 Feb aB, 4 Feb a, 6 Feb b, 8 Feb b,
23 Feb B, 24 Feb b, 1 Mar a, 7 Mar A, 11 Mar a, 1 Apr b, 7 Apr (a)
21 Apr b.
23 Nov aB, 26 Nov B, 12 Dec A.

1909 8 Jan b, 12 Jan b, 30 Jan aB, 15 Feb b, 14 Mar b, 26 Mar a, 1 Apr a
7 Sept b, 8 Sept b, 25 Oct b, 29 Oct a, 10 Nov b, 13 Nov a, 3 Dec (B)
18 Dec a, 20 Dec a, 29 Dec a.

1910 25 Jan A, 29 Jan B, 18 Mar b, 21 Apr b.
3 Sept b, 4 Sept a, 14 Sept (a), 14 Oct (a), 2 Nov ab, 9 Nov b, 11 Nov a
19 Nov a, 24 Dec b, 26 Dec b, 29 Dec b, 30 Dec b.

1911 1 Jan B, 2 Jan aB, 12 Jan B, 17 Feb B, 19 Feb b, 20 Feb b, 24 Feb b,
26 Feb a, 2 Mar b, 13 Mar (a), 14 Mar aB, 15 Mar (b), 25 Mar (a),
26 Mar (a), 27 Mar (a)
1 Oct Ab, 19 Nov (b), 20 Nov b, 21 Nov b.

1912 3 Jan b, 31 Jan b, 1 Apr b, 9 Apr ab
6 Sept b, 9 Sept b, 10 Sept b, 11 Sept ab, 1 Oct A, 31 Oct b, 12 Nov B
13 Nov B, 20 Nov b, 27 Nov b.

1913 8 Feb B, 18 Mar b, 5 Apr (a)
10 Dec b, 14 Dec b.

1914 6 Jan b, 15 Mar b.
13 Sept a, 18 Sept a, 19 Sept a, 28 Sept aB, 12 Nov ab, 14 Nov b,
6 Dec b, 19 Dec a, 29 Dec A.

1915 12 Jan ab, 16 Jan Ab, 15 Feb a, 19 Mar (A)
3 Nov a, 11 Nov aB, 13 Nov Ab, 14 Nov b, 13 Dec a

1916 8 Jan a, 13 Jan AB, 17 Feb ab, 8 Mar (a), 9 Apr b
13 Sept b, 14 Sept a, 24 Dec a

1917 2 Jan A, 4 Jan b, 9 Jan (A)b, 13 Jan a, 26 Mar b, 17 Apr a, 29 Apr b
21 Sept B, 8 Oct A, 9 Oct A, 25 Oct B, 27 Oct b, 10 Nov b, 26 Nov a,
2 Dec AB, 3 Dec a, 15 Dec aB, 17 Dec b, 25 Dec b.

1918 8 Jan ab, 11 Jan b, 28 Feb (B), 3 Mar (a)
30 Sept A, 23 Dec B.

1919 13 Mar a, 28 Mar ab, 16 Apr a, 28 Apr (b), 29 Apr b
27 Sept b, 26 Oct b, 27 Oct ab, 19 Dec Ab, 22 Dec A

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1920 14 Jan a, 21 Feb a, 27 Feb b, 7 Mar b, 19 Mar b
4 Dec AB.

1921 19 Jan Ab.
12 Sept A, 14 Oct b, 23 Oct A, 24 Oct a, 29 Oct aB, 1 Nov B, 5 Nov b
6 Nov Ab, 18 Dec ab, 31 Dec Ab.

1922 3 Jan ab, 4 Jan aB, 5 Jan b, 12 Jan ab, 26 Apr a.
15 Sept ab, 20 Sept a, 2 Nov B, 26 Nov b, 28 Nov b, 29 Nov a, 6 Dec Ab

1923 15 Jan ab, 24 Apr b
4 Oct A, 13 Oct b, 16 Nov b, 19 Dec ab, 20 Dec a

1924 2 Feb B, 4 Feb ab, 5 Feb aB, 1 Mar b
10 Sept b, 21 Sept B, 22 Oct (a)

1925 6 Jan b, 9 Jan b, 9 Mar B
14 Oct A, 25 Nov AB, 27 Nov b, 28 Nov ab, 10 Dec b, 23 Dec A,
25 Dec b, 31 Dec B

1926 22 Feb a, 5 Mar a, 6 Mar B, 10 Mar Ab, 12 Mar aB, 25 Apr (a)
10 Oct Ab, 12 Oct b, 26 Oct a, 20 Dec ab, 29 Dec aB, 31 Dec b

1927 1 Apr (a), 23 Apr b
12 Sept a, 23 Sept b, 29 Oct b, 11 Nov A, 26 Dec (a)

1928 5 Jan B, 3 Feb b, 30 Apr (a)
24 Nov b, 26 Nov ab, 28 Nov a, 7 Dec B, 8 Dec b, 27 Dec b, 31 Dec (a)

1929 15 Jan b, 31 Mar b, 20 Apr b, 30 Apr A
9 Oct b, 12 Nov aB, 12 Dec B

1930 2 Jan B, 16 Feb a, 19 Apr a
15 Sept a, 26 Sept b, 9 Oct b, 3 Nov AB, 4 Nov b, 7 Nov b, 11 Nov aB
23 Nov Ab, 27 Nov b, 9 Dec b

1931 17 Jan Ab, 24 Jan b, 25 Jan b, 12 Feb b, 5 Apr b
20 Oct B, 28 Dec b

1932 7 Jan b, 8 Mar a, 31 Mar b, 8 Apr b, 11 Apr b, 12 Apr b, 26 Apr b
14 Oct b, 15 Oct ab, 28 Oct a, 24 Nov b, 27 Nov B, 4 Dec b

1933 13 Feb b, 21 Feb b, 20 Mar a
14 Sept ab, 24 Sept b, 26 Oct Ab, 28 Oct (B), 2 Nov aB, 3 Nov b,
13 Dec (a)

1934 19 Jan b, 1 Feb (A), 8 Feb B, 19 Feb b, 20 Feb ab, 26 Feb b, 27 Feb b
23 Sept b, 14 Oct aB, 15 Oct a, 16 Oct b, 5 Dec (b)

1935 4 Jan b, 5 Jan a, 26 Jan AB, 2 Feb b, 17 Feb Ab, 25 Feb (b), 1 Apr b,
2 Apr ab, 5 Apr ab,
25 Sept A, 20 Oct B, 1 Dec b

1936 11 Jan a, 29 Feb (b), 17 Apr a, 19 Apr B
18 Oct aB, 20 Oct a, 27 Oct B, 28 Oct ab, 18 Nov A, 1 Dec AB

1937 29 Jan (a), 10 Feb B, 28 Feb B, 15 Mar a, 17 Apr a
10 Nov b, 12 Dec Ab

1938 30 Jan b, 2 Feb B, 11 Feb ab, 12 Feb aB, 13 Feb ab, 27 Feb b, 26 Mar ab,
3 Apr aB, 7 Apr b.

1939 26 Jan (a), 21 Mar a, 22 Apr b
11 Sept b, 12 Sept a, 14 Oct (A), 28 Oct (a), 19 Nov A, 28 Nov b,
2 Dec B, 5 Dec (b).

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1940 4 Mar B, 5 Mar ab, 27 Mar ab, 28 Mar ab, 30 Mar a, 15 Apr B
14 Nov a, 5 Dec b.

1941 25 Apr (a)
29 Oct aB, 30 Oct a, 7 Nov b, 7 Dec B, 24 Dec b, 25 Dec b

1942 26 Jan (A), 12 Feb b, 13 Feb ab, 2 Apr a
16 Sept b, 18 Oct a, 21 Oct a, 16 Nov b, 29 Dec ab, 30 Dec A, 31 Dec b

1943 2 Jan a, 14 Jan (A), 6 Feb b, 13 Feb a, 14 Feb b, 16 Feb a, 1 Apr ab,
7 Apr B, 26 Apr A.
7 Nov a, 12 Nov B, 14 Nov B, 25 Nov ab, 26 Nov b, 30 Nov b

1944 1 Jan ab, 4 Jan Ab, 9 Jan b, 4 Feb aB, 8 Feb ab, 10 Feb ab, 2 Mar aB,
11 Mar b, 12 Mar b, 13 Mar aB, 14 Mar a, 20 Mar a, 25 Apr a.
27 Sept b, 3 Oct b, 4 Oct b, 9 Nov b, 4 Dec A.

1945 4 Jan b, 7 Jan b, 8 Jan ab, 12 Jan (a), 17 Jan a, 19 Jan Ab, 28 Jan a
1 Mar b, 21 Apr b, 29 Apr b, 30 Apr ab
24 Sept ab, 27 Oct a, 6 Dec a, 13 Dec AB

1946 30 Jan a, 9 Feb Ab, 11 Feb ab, 20 Feb AB, 21 Feb aB, 23 Feb b
24 Feb a, 2 Mar a, 17 Apr b.
13 Nov b, 4 Dec b.

1947 9 Feb (a), 1 Mar b, 6 Mar (a), 9 Apr a, 24 Apr b
12 Nov b, 13 Nov a, 16 Nov a, 17 Nov b, 24 Nov b, 25 Nov b, 26 Nov ab
22 Dec A, 23 Dec a

1948 5 Jan (b), 8 Jan a, 10 Jan A, 9 Feb B, 9 Apr a
13 Sept a, 20 Sept b

1949 8 Jan b, 21 Jan B, 30 Jan b, 10 Feb a, 27 Feb b, 1 Mar AB, 18 Mar b
7 Apr a, 8 Apr b
26 Oct B, 27 Oct b, 4 Dec A, 15 Dec b, 26 Dec b

1950 12 Feb b, 14 Feb a, 11 Mar b, 24 Apr Ab, 26 Apr (b), 27 Apr a
7 Sept B, 26 Sept ab, 3 Nov A, 2 Dec B, 5 Dec b, 15 Dec B, 16 Dec b
17 Dec b

1951 23 Mar b, 10 Apr b, 13 Apr B, 27 Apr b
3 Nov b, 22 Nov ab, 10 Dec a

1952 11 Jan a, 12 Jan a, 18 Jan Ab, 20 Jan a, 27 Jan a, 8 Feb ab, 29 Mar (A),
30 Mar (a)
26 Sept B, 14 Oct (a), 6 Nov ab, 7 Nov Ab, 11 Nov b, 28 Nov (a) 18 Dec a,
21 Dec a.

1953 31 Jan B, 1 Feb AB, 2 Feb ab, 4 Feb b, 5 Feb a, 9 Feb a, 11 Feb (A)
12 Feb (ab)

1954 3 Jan B, 14 Jan b, 5 Mar b, 15 Apr b
29 Sept B, 7 Oct a, 25 Oct b, 9 Nov a, 22 Dec a, 23 Dec AB

1955 11 Jan b, 17 Jan ab, 18 Jan ab, 13 Feb (a), 16 Feb B, 17 Feb B,
24 Feb (a), 4 Mar b, 5 Mar ab, 6 Mar (a), 17 Mar b, 11 Apr b, 13 Apr b.
6 Oct b, 17 Oct b, 18 Oct A, 21 Oct b, 22 Oct A, 25 Oct b,
28 Oct b, 23 Nov b, 18 Dec b.

1956 2 Jan a, 15 Jan a, 21 Jan B, 2 Mar B.
6 Oct ab, 29 Oct a, 25 Nov b, 27 Nov aB, 29 Nov a

1957 10 Jan b, 12 Jan b,
12 Sept a, 13 Sept b, 14 Sept B, 15 Sept b, 3 Oct b, 6 Nov b, 10 Nov (a),
22 Nov b, 13 Dec (a)

1958 7 Jan A, 11 Jan aB, 19 Jan b, 22 Jan a, 6 Feb b, 16 Feb b, 17 Feb b,
18 Feb b, 20 Feb b, 25 Feb (A), 26 Feb b, 6 Mar b, 7 Mar B, 9 Mar a,
27 Apr b
25 Sept B, 16 Oct ab, 17 Oct a

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1959 3 Jan ab, 4 Jan b, 7 Jan (a), 9 Jan AB, 11 Jan ab, 12 Jan A, 24 Jan ab,
7 Apr b, 30 Apr (a)
20 Oct b, 28 Oct B

1960 17 Jan b, 20 Jan AB, 28 Jan (a), 29 Jan A, 15 Feb b, 16 Feb B, 17 Feb aB
20 Sept a, 10 Oct ab, 11 Oct ab, 12 Oct AB, 30 Oct (a), 6 Nov b,
18 Nov a, 28 Nov b, 20 Dec a

1961 4 Jan b, 6 Jan (B), 1 Feb A, 7 Feb B, 18 Mar b, 20 Mar b, 21 Mar a,
27 Mar b
18 Oct AB, 19 Oct AB, 31 Oct B, 3 Nov aB, 4 Nov ab, 13 Nov (A) 17 Nov (a)
5 Dec B, 6 Dec b

1962 5 Feb ab, 8 Feb ab, 12 Feb B, 13 Feb b, 14 Feb AB, 16 Feb B, 17 Feb AB,
26 Feb (a), 15 Apr (a).
17 Sept b, 18 Sept a, 15 Nov b, 18 Nov B, 19 Nov b, 10 Dec b, 12 Dec b,
13 Dec B, 16 Dec A, 21 Dec a.